LAPS Storm Relative Helicity White Paper

Dan Baumgardt SOO - La Crosse WI
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Background

Storm-relative helicity (SRH) began being used by operational forecasters after work by Dr. Robert Davies-Jones found it useful as a measure of tornadic potential in supercell environments (Davies-Jones et. al., 1990). The SRH is defined as:

SRH = { (v - c) . W dz

where v = actual ground-relative wind vector, c = storm motion vector, (v - c) = storm-relative wind vector, W = horizontal vorticity vector, the dot "." represents a mathematical dot product, and the "{" represents a vertical integration over a specified depth (usually the lowest 2 or 3 km of the atmosphere). Units are m2/s2 (i.e., meters squared divided by seconds squared).

Davies-Jones used actual storm motion from 28 cases and proximity soundings to arrive at the following "guidance values":

SRH = 150 to 299:	Weak tornadoes (F0 and F1) possible.
SRH = 300 to 449:	Strong tornadoes (F2 and F3) possible.
SRH > 450:	Violent tornadoes (F4 and F5) possible.

The Storm Prediction Center (SPC) began to forecast storm motion to use this technique *apriori* in the early 1990's. The SPC storm motion (SSM) was assumed to be 1) 20 degrees to the right of the 0-6 km mean wind and at 85 percent of the 0-6 km mean wind speed for 0-6 km mean wind speeds greater than 30 kts, or 2) 30 degrees to the right at 75 percent of the speed for 0-6 km mean speeds less than 30 kts.

In the operational forecast environment, SRH has been typically calculated in the NWS using the SSM with a forecast storm motion vector of 30 degrees to the right of the 0-6 km mean wind and 75% of the magnitude of the 0-6 km mean wind. The above table of values are then used to operationally assess the supercell and tornadic potential of the environment.

Recent Trends

Since 2000, a new storm motion has been gaining widespread use in the operational environment: Bunkers et. al. (2000) storm motion (BSM). The BSM technique calculates a forecast storm motion similarly to the SSM, yet different. The BSM uses a) the 0-6 km mean wind vector b) the 0-6 km shear vector, and c) a deviation vector of 7.5 m/s to either side of the (a) and (b) interaction (see paper). The research submits it is a better and more accurate method of forecasting a storm motion *apriori*.

This BSM is now used in the NCEP RUC and Eta models as input to the 0-3 km SRH calculation. However, LAPS uses quite a different storm motion.

LAPS storm motion and SRH

The AWIPS LAPS storm motion (LSM) is calculated differently than either the BSM or SSM. A vector is calculated for the surface to 300mb mean wind. A shear vector for the surface to 300mb layer is also calculated. The storm motion is assumed to equal the mean wind + 0.15 times the shear vector (rotated for a right mover by a 90 degree angle to the shear vector). When reviewing various datasets, the LSM is often quite different from the BSM visually. Since storm motion is a key ingredient to the SRH calculation, comparing a SRH value from the NCEP RUC/Eta model to LAPS yields different solutions.

Local Research

The hourly LSM and BSM were calculated for three different days (from three different months). 180 hourly LSM and BSM gridpoint comparisons produced the following statistics:

Average Direction Difference (LSM-BSM)	-24.7 deg
Standard Deviation	23.6 deg
Average Absolute Direction Difference (LSM-BSM)	27.5 deg
Average Velocity Difference (LSM-BSM)	-3.8 knots
Standard Deviation	6.4 knots
Average Absolute Velocity Difference (LSM-BSM)	5.7 knots

From these data, the LSM is shown to be, on average, about 25 degrees to the *left* of the BSM storm motion. Thus, the BSM creates a 25 degree more deviant, and to-the right storm motion than the LSM. The standard deviation was about the same (24 degrees). Thus, roughly 60% of hourly comparisons yielded a LSM/BSM difference from 0 degrees to nearly 50 degrees. The LSM was also found to be 3.8 knots less, on average, than the BSM.

This has direct implications on the SRH calculation! The more right-moving the storm motion in a typical severe weather environment, the greater the SRH. *Thus, one can assume the BSM, which averages 25 degrees to the right of the LSM, would produce a larger SRH value in the majority of events and hours.* Furthermore, since the RUC and Eta both use the BSM, ***the LAPS SRH using the LSM would typically be less, comparatively***.

We also performed analysis on about 90 hours of Profiler versus LAPS SRH output spanning over 7 convective events. When the Profiler sampled <u>positive</u> 0-3km SRH, LAPS SRH values were only 64% of that amount. 71% of the hours in our study showed LAPS SRH values were less than those sampled via the profiler BSM SRH (see figure). The correlation coefficient was a depressing 0.21 between the two datasets which should lead FSL and the NWS to revisit the LAPS SRH.

Average 0-3km SRH Profiler	112 m2/s2
Average 0-3km SRH LAPS	71 m2/s2
Percent LAPS SRH versus Profiler SRH	64 %
Correlation Coefficient	0.21
Percent hours with LAPS SRH < Profiler SRH	71 %

Currently on the AWIPS system, the SRH is used operationally to diagnose convective environments simulated in the RUC, Eta, and LAPS models. Three scientific and operationally problematic areas are:

1. Inconsistency in storm motion calculations (BSM versus LSM) often times provides conflicting views of the tornadic potential from the models even when the ambient wind profile is modeled exactly the same from the surface to 3 km.

2. LSM would, on average, produce lower SRH values than both observed and versus BSM SRH.

This would tend to wrongly minimize tornadic threat.

3. LSM is providing SRH values which could potentially be very inconsistent with thoseSRH values published by Davies-Jones (1990) and widely used in NWS offices. This again would tend to wrongly minimize tornadic threat.

Proposed Action

As soon as possible, the LAPS storm motion should be adjusted in the WFO AWIPS LAPS version to use the BSM technique. Using the BSM will provide the NWS operational forecaster with SRH values consistent across the NCEP Eta, NCEP RUC, and FSL LAPS models. The LAPS SRH calculation should also be investigated for accuracy ensuring it is consistent with the published literature (Davies-Jones, 1990). Erroneous guidance in tornadic environments will be avoided and the NWS mission will be better served.